APH Student Speech Plus Calculator Materials

Frank L. Franks

American Printing House for the Blind

Louisville, Kentucky

1980

Running Head: APH Student Speech Plus Calculator Materials

APH Student Speech Plus Calculator Materials

A. Background and project objective

Blind students in the elementary and upper grades are not able to use the calculator independently in the mathematics classroom because supportive, supplementary materials using the APH Student Speech Plus Calculator are not available. Specific materials do not exist which are designed to provide blind students with practice in performing basic math operations and to facilitate their independent use of the calculator in computation and solving problems that appear in mathematics textbooks.

The principal objective of this project is the development of computation and problem solving activities designed to provide the blind student with practice materials to facilitate his independent use of the calculator (1) in performing fundamental operations and (2) in solving problems that appear in mathematics textbooks.

B. Supporting documentation

APH Student Speech Plus Materials Needs Meeting. In November 1977, 14 participants representing general and special education, teacher education, industry, the California Clearinghouse Depository for Handicapped Students, and the APH met in San Francisco to explore types of materials needed by blind students for understanding calculator application. This meeting was in response to a need for calculator materials for blind students which had been expressed by educators across the United States. Immediate needs for materials recommended by participants included a minimum of three sets of materials:

1. Materials to introduce the APH calculator to primary-elementary grade visually handicapped students
2. Workbook practice materials which focus on computation for elementary grade students

3. More advanced materials which emphasize problem solving for upper elementary junior high and secondary students

A copy of the needs meeting report is included in Appendix 1.

C. APH Speech Plus Materials description

Three manuals were developed for use by blind students with the APH Speech Plus Calculator. They are described in the following paragraphs.

Computation and Problem Solving for Young Adults. The inspiration for this publication came from the APH Student Speech Plus Calculator: An Aid to Successful Mathematics Learning (1977) by Dr. William Emile Lamon, Mathematics Professor, University of Oregon, Eugene. Dr. Lamon's original work is a calculator-based program designed "to enable its users to successfully master everyday, fundamental mathematics." Dr. Lamon directs students "to review in their regular mathematics textbook their understanding of basic operations, algorithms, rounding, and significant figures, prior to calculator usage." The original is a textbook extension, done under contract to the American Printing House for the Blind (APH).

This self-instructional version was rewritten by Dr. Lamon; by Anthony Evancic, mathematics teacher, Western Pennsylvania School for Blind Children; and by Tuck Tinsley III, mathematics teacher, Florida School for the Deaf and Blind.

It draws from the original for overall format, for scope, and sequence of tasks, but approximately 70% of the content has been rewritten to insure its usability as a self-instructional program for young adults independent of additional textbook instruction. The content is presented in a simple, direct format which focuses on computation and problem solving. Generally, each lesson presents computation exercises and is followed by "word problems" which employ operations from the computation exercises in their solution. The problem solving exercises are more oriented to daily living and to real life situations

than to stereotyped word problems traditionally found in mathematics textbooks. The content and its presentation, however, make this publication suitable for students as early as junior high school.

A copy of the Table of Contents is included in Appendix 2.

Elementary Computation. This manual emphasizes fundamental operations in computation. Representative numerical exercises appear in each lesson. These are followed by verbal presentation of numbers in simple word problems. A considerable portion of the first volume is devoted to introduction to and use of the calculator. This volume can be used with students as early as grade 4. When a student has successfully completed the first volume, he may proceed to the second volume.

A copy of the Table of Contents is included in Appendix 2.

Elementary Problem Solving. This volume focuses on problem solving activities. "Criterion" activities from the first volume introduce each lesson. If the student can perform these tasks with ease, he can continue the lesson. If for some reason he has difficulty, he should return to the appropriate section in the first volume for remediation. Representative problems from the mathematics curriculum are included, and a substantial number of the problems are oriented to real life situations.

A copy of the Table of Contents for this volume is included in Appendix 2.

The general format for each lesson includes an example for the student to work through, step by step, with the answer given.

Although the publications were written as practice materials, the three volumes can be used for a sequential program of basic instruction in general mathematics, and as a mathematics program for vocational students.

D. Materials development and evaluation

Development. Computation and Problem Solving for Young Adults was an

extension of a manuscript written on contract by Dr. William E. Lamon. Writing sessions were held including the project director, Tony Evancic, Tuck Tinsley III, and Bob Glass. In these sessions the original work was rewritten (as described in Section C) and reviewed and edited by Evancic, Tinsley, Glass, and the project leader.

The Elementary Computation and Elementary Problem Solving manuals were conceived in a meeting in Louisville in the summer of 1978. Five expert teachers of blind students in mathematics, two from public and three from residential schools, met to discuss the content of the manuals and to prepare a tentative working outline. Copies of these outlines are included in Appendix 3.

Two levels of formative evaluation were utilized in the development of the materials.

Level 1: Skeleton lessons were sent to participating teachers who critiqued the lessons. Each teacher used the materials with students, suggested changes/additions/deletions, and wrote simple "word" problems which they felt were appropriate transition or lead-in problems for the second volume. This information was returned to the senior author. He incorporated this information into the draft of the first volume.

Level 2: The complete draft was sent to Maggie Ritchie, Pasadena City School District, California, who critiqued the draft (as in Level 1) and evaluated the appropriateness of the volume for use by blind students who are mainstreamed into regular classes. Upon completion of the evaluation, the draft was returned to APH. The procedure was repeated in development of the second volume.

During the summer of 1979, Tinsley, Evancic, Ritchie, Glass, and the project director met for revisions in the final draft. Subsequently, these drafts were sent to the remaining two participants for their final edit/reviews. These reviews were examined, and final copies prepared at APH for publication in large print and in braille.

APPENDIX 1

USE OF THE APH STUDENT SPEECH PLUS CALCULATOR BY YOUNG BLIND STUDENTS

A Preliminary Needs Meeting Report

held at

The Clift Hotel

495 Geary, at Taylor
San Francisco, California
November 18-19, 1977

by

The Clearinghouse Depository for Handicapped Students, California,
The Teacher Education Center, San Francisco State University,
and
The American Printing House for the Blind, Louisville, Kentucky

Frank L. Franks, Editor

American Printing House for the Blind
Louisville, Kentucky
September 1978

Meeting Organizer

Mr. Fred Sinclair, Director
Clearinghouse Depository for Handicapped Students
California State Department of Education
721 Capitol Mall
Sacramento, California 95818

Consultants and Participants

Dr. Phil Hatlen
Prof. Special Education
San Francisco State University
1600 Holloway Avenue
San Francisco, California 94132

Dr. Sally Mangold
Asst. Professor Special Education
San Francisco State University
1600 Holloway Avenue
San Francisco, California 94132

Dr. Rose-Marie Swallow
Associate Professor
Department of Special Education
California State University, Los Angeles
5151 State University Drive
Los Angeles, California 90032

Ms. Maggie Ritchie
V.H. Teacher, Elementary
535 Prospect Boulevard
Pasadena Unified School District
Pasadena, California 91103

Mr. Tom Kellis
Resource Teacher, High School
Berkely High School
2246 Milvia Street
Berkeley, California 94704

Mr. Arthur Kessner, Coordinator
Elementary Mathematics Concepts with Calculators (EMC^2)
Lawrence Hall of Science
University of California, Berkeley
Berkeley, California 94720

Mr. Douglas Ritchie
Mechanical Engineer
Vice President
Konigsberg Instruments, Inc.
2000 E. Foothill Boulevard
Pasadena, California 91106

Dr. Frank Franks
Research Scientist
American Printing House for the Blind
P.O. Box 6085
Louisville, Kentucky 40206

Mr. Bob Gowan
Itinerant Teacher, Elementary and Secondary
San Mateo County Schools
333 Main Street
Redwood City, California 94063

Ms. Sue Benton, Resource Teacher
Lawton Elementary School
1570 31st Street
San Francisco, California 94122

Mr. Phil Mangold
Resource Teacher, Jr. Secondary
Castro Valley Unified School District
3300 Norbridge Avenue
Castro Valley, California 94546

Mr. Rick Plescia, Sales Representative
Telesensory Systems Inc.
3408 Hillview Avenue
Palo Alto, California 94304

Ms. Gayle Brugler, Training Manager
Telesensory Systems Inc.
3408 Hillview Avenue
Palo Alto, California 94304

Section 1: Introduction and Objectives

The availability of the Student Speech Plus Calculator on Federal Quota from the American Printing House for the Blind is generating new interest in old curriculum areas in California. Preparatory to distributing the calculators to schools, the Clearinghouse Depository for Handicapped Students, the Teacher Education Center of San Francisco State University, and the Research Department of APH sponsored a needs meeting on Use of the Speech Calculator by Blind Students in San Francisco on Saturday, November 18-19, 1977. Fourteen participants representing general and special education, teacher education, industry, the research department of the American Printing House for the Blind, and the California Clearinghouse Depository for Handicapped Students were present.

This special conference of individuals afforded the opportunity for educators and manufacturers to come together in exploring potential educational methods and values of the calculator, as well as the development of hard- and soft-ware which can facilitate student learners in understanding calculator applications.

Objectives

Preliminary objectives set forth for the workshop were:

(1) To identify materials for teaching primary and elementary grade children manual keyboard operations and functions of the calculator.

(2) To explore beginning and advanced calculator application in the mathematics curricula for mainstream and special classroom instruction.

(3) To evaluate the mechanical functions and language capabilities of the calculators in terms of their appropriateness for effective use by blind students in the mainstream and/or in special educational settings.

Some key topics included: (1) A study on elementary school mathematics

with calculators conducted through the Lawrence Hall of Science of the University of California at Berkeley. Summaries of these reports are presented in Section 2, and (2) a slide presentation of a calculator instructional program for blind students in the Pasadena Unified School District.

Applications of calculators for blind students presented by Fred Sinclair from a national survey conducted by the California Clearinghouse Depository for Handicapped Students (through the organization of State consultants for the visually handicapped) also are included in Section 2. Special needs related to the provisions of inservice training for teachers were discussed.

Throughout the workshop a number of suggestions and recommendations for further investigations into the development of child-use materials, aids, devices, and teacher instructional guidelines were proposed. These suggestions and recommendations are included in Section 3 of this report.

Section 2: Calculator Applications in Mathematics

Presentation by Arthur Kessner: Calculators in the Elementary Grades (The EMC^2 Project at Berkeley)

Mr. Kessner discussed the value and use of calculators in the elementary grades. He emphasized the use of the calculator to link quantities of concrete objects to visual display in the calculator window. He introduced the calculator to young students as young as four years of age using limited access keyboards, a concept which he invented. The first keyboard masked numbers other than 1 and 0. Young students were taught to count using tiny plastic frogs. As each student placed a frog and pushed 1+, the calculator instantly provided feedback of the next number in the counting sequence. The frogs (concrete objects) were linked with abstract symbols and related to a fundemental mathematical concept, "one-to-one" correspondence. Variations in activities allowed students to engage

in problem solving and to seek solutions to problems in different ways. For example, students counted up to their ages. They were asked to put their street number or telephone number in the window.

The use of a second limited access key displaying 0-5 was used to focus on ways in which small numbers build large numbers. Students were asked to make a 6 appear in the window and the number of ways to do it. The calculator display allowed students to apply and test their understanding and skill development.

Mr. Kessner summarized the characteristics of the EMC^2 materials:

A central project aim is to develop children's quantitative thinking as early as possible in their education. This means giving children many different kinds of practice in constructing, using and playing with numbers in a mathematically rich environment of manipulatible objects. Children learn by interacting with their environment. A calculator, with its built-in energy source and system of logic, can be a unique and positive encouragement for this interaction. It almost says to children, "Play with me." It can arrange information that children give it and can respond quickly with numerals in a lighted display to the surprise and delight of most children.

Very young children can build and show off large and small numerals easily on the calculator without having to wait for their fine motor skills to develop. The frustration of learning how to write with a pencil does not have to interfere with the acquisition of mathematical concepts.

The EMC^2 materials are designed to supplement the regular school mathematics program, not replace it. Therefore, the materials are intended to be compatible with many teaching styles and many different classroom environments, such as open and self-continued classrooms.

In the primary grades

To encourage quantitative thinking in the primary grades, experiences are designed around three broad concept areas:

1. The Nature of Numbers

What numbers "look like" (differences and similarities between printed Arabic, calculator and hand-written numerals). Names of numbers. What and how numbers can describe (bunches of things counting).

2. Ordering and Combining Numbers

Relations that are defined on groups of numbers (more than, less than, between, equality). Operations that one can perform on numbers (addition, subtraction). Making larger and larger numbers.

3. Uses of Numbers

Estimation. Applications. Problem solving. Elementary Statistics.

In the upper elementary grades, interactive experiences with concrete models of mathematical concepts are again provided. For example, in Coin Carnival, a 2nd and 3rd grade module of activities, children explore such basic skills as counting by 1's, 5's and 10's and well as trading and comparing amounts of money and making change--real world applications of their counting skills. Children begin actively using money, then do activities with pictures of money, and finally do activities with materials using printed numerals.

In the upper grades

Other upper grade design considerations here included using many different models for a particular mathematics concept such as place value or multiplication. Many children seem to have an easier time recognizing and generalizing mathematical ideas when several different models are used. This strategy also accommodates a variety of learning styles. A third design objective is for the activities to be repeatable. Ideally, children will elect to go back to the activities again and again. During this repetition, children may learn to recognize underlying processes--for example, the process which solidify such concepts of multiplication as repeated addition. A fourth design objective is that the materials permit and encourage peer teaching. Most of the activities are for small groups of children, with the teacher playing a secondary role after the activity is introduced. Finally, in order to hold the interest of both skillful and less skillful children an effort was made to obtain a balance of skill and chance in all of the activities. An activity depending entirely on skill may be intimidating to less apt children, while a game relying purely on chance may not challenge more advanced children.

Mathematical topics for the upper elementary grades include: place value, comparisons of 1, 2, 3 and 4 digit numbers, change making skills, more advanced counting, number operations, decimals, measurement, estimation and problem solving.

Evaluation and development

Approximately 900 students were used in testing the kindergarten and first grade materials using the limited access machine in the fall and winter of 1974-75. The test sites spanned a wide range of socio-economic levels in urban, suburban, and rural areas of the United States. Results of these field tests substantiated the value of the materials and provided ideas for expansions and revisions. The materials were published in preliminary commercial form the following summer by Texas Instrument, Inc. All the materials bear the copyright of the Regents of the University of California, Berkeley. Materials for grades 2-3 were subsequently developed and are undergoing final field testing at this time. Two sets of materials have also been developed for grades 4, 5, and 6, one set of

which was published in 1975 and one set is awaiting final editing.

Conclusion

Mr. Kessner suggests that calculators probably have value just being in the classroom. However, like any other instructional aid that a teacher uses, it is how the teacher uses the aid that will ultimately decide its worth. Kessner emphasizes the importance of teacher observation to determine where individual students are in their concept and skill development, and second, the provision of materials appropriate to that development, whether the materials are calculators or other aids. He further suggests that the calculator be viewed as the new algorithm in multiplication which offers step by step procedures to save time in calculation.

A description of the ABLE^{TM} materials is presented at the end of this report.

Presentation by Maggie Ritchie: Possibilities, Potentials and Promises of the Electronic Talking Calculator

Experimentation with numbers has been a luxury of the most gifted math students; the talking calculator has freed the visually handicapped student to try,to sample, and to test the many different patterns and methods of solving problems. The talking calculator frees the student to recognize the problems operation, to investigate and to select the best method for solution, to compute the answer accurately, and to check the solution against the original problem. The students are free to enjoy math.

Our interest in electronic calculators as a learning device for the visually handicapped student goes back to about five years ago. We had a student enrolled in Algebra II at that time. Although a gifted math student, he was experiencing considerable difficulty keeping up with the amount of class work. This student's problem of visual efficiency was compounded by the fact that the regular students

were using electronic calculators, enabling them to move along through the class work more rapidly. The result was that, although Danny had been able to keep up previously, he was no longer in a competitive position. After consulting with the algebra instructor, it was determined by the visually handicapped staff that this student's difficulties were within the realm of our Special Education operations and that such money should be spent to purchase an electronic calculator with the needed requirements. The specific needed requirement of course, was a large readout.

After investigation, the most satisfactory calculator that could be used with a low vision magnifier was selected. We purchased this calculator at a cost of nearly $400.00. Our staff's concern in calculator math grew. As the market for calculators became more competitive, we investigated other simpler functioning models claiming to have a large print readout suitable for the visually handicapped. We purchased two of these instruments and found them to be highly unsatisfactory. The readout, although green and brighter, was still not adequate. The instrument itself was not a quality device, resulting in poor student performance. Continued use with students was abandoned.

With this background in mind, one can imagine our interest when we heard the reports concerning TSI's development of the Speech+ calculator. Dr. Swallow at Cal State, L. A., knew of Pasadena's interest in the calculator's use as an educational tool and indicated that there was some possibility TSI might have available or be able to locate a number of Speech+ calculators for field work. At that time, we did not have the funds needed to purchase enough Speech+ calculators to do an adequate investigation nor did we have any educational justification to do so. We were mainly operating on theories that we observed as a happening of regular students' use of calculators and the knowledge that if our students were having a hard time competing in math classes

now, what was it going to be like in five years.

These things have come to pass quicker than our concerns would allow us to imagine. The calculator that we purchased 5 years ago can be found today with the same functions improved for $29.95.

Where are we today with TSI's Speech+ calculator? Certainly not in an Algebra II Class, but perhaps more importantly starting at the beginning in the elementary classroom -- looking at our students, what their needs are now and what the future holds for them in the competitive world of math.

We have a series of slides with this year's students showing some of the activities we have been involved with in our talking calculator program. We hope they will provide an additional dimension for understanding of our program, as I discuss the student curriculum and results.

The Tools. Between TSI and Smith-Kettlewell, we obtained on loan 3 talking calculators for use with our students. It was decided to use the Key Math Diagnostic Arithmetic Test as an assessment tool in order to develop individual student profiles of basic math skills. The test was administered to each student during the first 6 weeks of the 1976 school year. The talking calculator was not used during the testing situation. The students were encouraged to use the low vision aids they were accustomed to. Since all students were large print readers, the closed circuit TV was the only aid required. The computational part of the test was administered in large print.

The Students. We had an academically strong group of upper elementary fifth and sixth graders to work with. I felt they could work as a group or individually with the Speech+ as they developed advanced computational skills in the basic functions of the calculator. I knew these students well since each one had been in the program for at least a year prior to 1976. We were also aware that three of the students, now in the eighth grade, were quickly approaching the difficult junior high years. We felt we still had the time and

freedom to experiment, which these students would not in junior high, unless they are enrolled in remedial math--a situation we hoped to avoid.

All students were legally blind large print readers. (This year we have a braille student who is new to the program.) Collectively, the students presented a great specific learning disability in math--they hated it! This fact was well documented by the on-going verbal assault they had with the subject matter. It was not uncommon for them to vent their math frustrations when they came to the resource room with such profound statements as: "Math makes me sick," "I don't understand how to do the problems." As our students became familiar with the talking calculator and became involved in math experiences in the resource room, these experessions gave way and the true nature of their emotional feelings became obvious--these students had been very fearful of math, not haters. They were afraid of making mistakes.

It is difficult to designate a specific "when to use the calculator" other than incorporating its instruction and use into the total math program. The more the calculator is used the more ways students will find to use arithmetic. We know now that somehow these calculators must be put into the hands of our students and kept there--stashed away behind locked doors or used only under specific instructional situations is not going to help in the learning of math. In order to implement this understanding of calculator math, it was necessary to assume the math program for each student. This was easily done since the classroom teacher was anxious for any help available. This meant that when the visually handicapped students came to the resource room, the primary subject matter was math. The math grades for the year were based on the work completed in the resource room.

The feelings of accomplishment through using the talking calculator lead to greater student and teacher effort and thus to greater success. We found

that the talking calculator can aid in encouraging exploration and experimentation. It can stimulate and satisfy intellectual curiosity.

Curriculum. Our field trips were always great adventures--we were a sensation! Checkers have a hard time with three different talking calculators, each telling a different total and none agreeing with the bill.

Our original field work goals were the following:

1. To develop a method of sequential operations by which elementary visually handicapped students would learn the basic functions of the Speech+ calculator.

2. To work out a curriculum of math instruction using the calculator as an educational tool for grades 4, 5, and 6.

The first goal was achieved through a workbook format. With the help of a blind college student, who had been in our program and a former high school student of mine, we developed the Speech+ calculator into a personality called Mr. Swap. Mr. Swap's character, of course, is that of the ever-ready robot. The workbook that resulted uses this theme throughout. We hoped to put a little childhood fantasy into the operation, and of course it was easy since the calculator lends itself to any such fun. During this period we had what we thought of as a profound and baffling problem: What to do with the ever present .00. We were greatly concerned with the confusion this perseverating .00 was going to create among our students. What was not apparent at the time, but what has become obvious to us now, is the fact the .00 really didn't bother the students that much--they became used to it very easily. We also became not so much concerned in what the talking calculator would do, but more in what a visually handicapped student could do with it!

Probably one of the most interesting early experiences I had with the students and Mr. Swap concerns the sequence of activities developed to introduce the students to the calculator and its functions. I really never had a chance to present the logical sequence of activities that had taken so much of my time

the previous summer. Once the talking calculator was in the hands of the students, they were on their way--with or without the teacher. After the initial introduction certainly some time was spent learning the basic functions and how things worked. But this all took place with such ease and acceptance that very little time elapsed before problems were being attempted.

Another fact became clear very early in the school year and that involved curriculum materials. The amount of work the students were able to complete was remarkable. As a result, curriculum material development was soon dropped in a frantic effort to keep up with the students. We had earlier resolved the .00 problem by deciding to base the math program around the use of money. We used appropriate parts of workbooks available from the American Printing House for the Blind. Some of this material included language arts experiences, as well as math. Also workbook publications from Frank Richards Co., which we had enlarged for group activities. Throughout the year we worked through the Sullivan Programmed Math books, using them for independent student/calculator experiences. The talking calculator helped our students build basic math concepts as well as perform computations readily. Using the talking calculator in the resource room enabled the teaching staff to expose visually handicapped students to greater concepts and ideas.

How and where does the Speech+ calculator fit into the existing math program? In our program we have tried to join the talking calculator with every traditional approach to mathematical education we knew of. However, the so-called "pencil and paper" arithmetic still remained the basic structure of the learning operation!

We found as we worked along, that students did not always rely on the talking calculator for answers. At some point each student began to use his own knowledge to work out the solutions to problems. As this group endeavored to find the easiest way to compute the number of kernals on each ear of corn, it was

Debbie's voice we heard say "Hey, I can do this myself."

The students quickly began to recognize mistakes due to errors during entry of numbers or functions that occur occasionally. They became self-motivated to find out what had happened to cause an impossible answer to be heard. It was easy and quick to go back and trace the operation to its beginning and find the error. The error was never a tragedy; mistakes became something one could fix. In fact, it became possible for all math papers to have happy faces and 100%'s.

The number line is a tool from APH and is useful in helping students understand addition and subtraction. The talking calculator is used to check and reinforce the answers the students arrive at using the number line to help learn basic facts. The number line can also be used with the talking calculator and more advanced elementary students to easily investigate the world of negative numbers. Talking calculator math experiences give variety through many different concepts and most important, frequent success for the students.

As early as 1937 the question of a calculator's use in the classroom was being considered. This early work indicated positive results in terms of student achievement when using calculators. The problem confronting these investigations was one of a technical nature--the calculators were mechanical and subject to jamming, resulting in an unhappy student with a very wrong answer.

The results we see today of talking calculator math is very appealing; there is great interest in the calculator from all other students and teachers. It turns long faces into smiley ones on the outside, and helps our visually handicapped students to be far more assured about themselves on the inside.

The program as it went along with its bits and pieces of curriculum from here and there, proved to be a very positive kind of experience. The end of the year evaluation indicated the students had, in fact, become far more proficient in terms of their understanding of math than we could ever have projected.

The talking calculator is a teaching aid that is enduring, respectable, and lasting. The students have complete control of it--the power is theirs at last. What a wonderful learning experience!!!

Presentation of the California Clearinghouse Survey Results

Fred Sinclair presented the following applications from the Survey:

Teaching number concepts at the primary level.

Teaching general and remedial mathematics.

Improving computational skills, speed, and accuracy (braille is time consuming and often inaccurate).

Aiding those students who have mastered basic operations and enabling them to complete assignments competitively with sighted students, even in those classes where regular calculators are not in use.

Providing an alternative to braille readout calculators for visually handicapped students in those classes where sighted students use regular calculators (especially for non-braille readers).

Replacing or supplementing the abacus or slide rule for those students who cannot use or who refuse to use these instruments because they are too cumbersome.

Teaching advanced mathematics and science concepts which are too complicated for traditional pencil and paper calculations by visually handicapped students.

Aiding multihandicapped students who have specific learning disabilities or who lack sufficient fine motor coordination to operate the abacus.

Aiding the mentally retarded, visually handicapped students who are unable to learn math by rote.

Enabling self-checks of mathematical computations.

Allowing greater independence in mathematics.

Increasing employment potential through work experience classes and vocational training.

Enabling students to become familiar with the use of talking calculators and helping them to develop skills for independent living and for use in a variety of other school subjects (e.g., bookkeeping, business courses, geography, and cooking).

Section 3: Suggestions and Recommendations

Although time limitations prohibited in-depth investigation and pursuit of the objectives of this needs meeting, a number of suggestions and recommendations were offered for consideration.

1) We recommend that APH sponsor and conduct a national conference on use of the talking calculator in math instruction for visually handicapped students. The purpose of this meeting would be to examine the recommendations of the California meeting and to revise, expand, and edit those recommendations. Representation at this meeting should include persons experienced in use of the calculator, resource and itinerant teachers of the visually handicapped, and certified secondary teachers of mathematics. Experts should be included who are experienced in teaching and in developing curriculum for hand-held calculators for sighted children, and those involved in the technology of production of calculators.

2) We recommend that APH develop, prepare, and disseminate teacher/student instructional materials, with manipulative aids, for introducing the use of the APH Student Speech Plus Calculator to visually handicapped students across grade levels where the calculator can be utilized.

3) We recommend that a minimum of three sets of math curriculum materials be considered for development by APH and these include:
   (1) Materials to introduce the APH Calculator to primary-elementary grade visually handicapped students

(2) workbook practice materials which focus on computation for elementary grade students

(3) more advanced materials which emphasize problem solving for upper elementary, junior high, and secondary students

4) We recommend that APH review and inspect existing APH publications (e.g., "The Money You Use") and commercial publications (e.g., Texas Instrument programs) to determine those which are most appropriate for adaptation for use by visually handicapped students with the APH Student Speech Plus Calculator. These publications as reviewed and selected should be compatible with the curriculum materials in item (3) above. An expanded review should include all materials appropriate for use with Speech Plus at different levels.

5) We recommend that, as APH develops materials for use with the calculators, the representatives of this needs meeting be included in the development and/or selection, teacher/student field-testing, and evaluation of these materials whenever feasible.

6) We recommend the establishment of an in-service process in the following pattern:

(a) A national in-service training workshop (e.g., EMC^2), 2 days in length, be offered. Participants will be one representative of each University training program and one representative selected by each State Department of Education.

(b) Each participant will in turn provide in-service workshops for resource and itinerant teachers and parents of visually handicapped in his/her regional or geographic level, based on information and materials offered at this national workshop.

(c) A BEH proposal will be submitted, modeled after the Optacon Dissemination Project, to provide funds for the workshops.

(d) APH participate in an initial "model" workshop since APH will be the major source of calculator hard- and soft-ware.

In-service training planning and development should be one of the goals of the national conference.

7) We recommend that efforts be made to provide a calculator for visually impaired students at a lower cost, preferably under $100.

8) We recommend that APH establish, support, and publish twice-yearly, a newsletter for users of the Speech Plus Calculator, to share:

(a) Commercial and teacher-made ideas and applications for the APH Speech Plus Calculator.

(b) New APH, commercial, and teacher made curriculum methods and materials as they are developed and are available

(c) Personal teacher/student experiences using Speech Plus in the classroom in:

1. Academics studies
2. Fun and games
3. Daily living

The following suggestions and recommendations related to the development of appropriate instructional materials using the APH Student Speech Plus Calculator were made.

1. Identification of prerequisite math skills (e.g., manipulation, number concepts) required by beginning students to operate the calculator.
2. Development of instruments to assess students' abilities to perform tasks underlying these calculator math readiness skills.
3. Development and adaptation of (sequenced) activities with manipulative aids for operating the calculator.

4. Preparation and inclusion of criterion tests to evaluate student progress in performing computational tasks using the calculator. Tests should include items for use with the calculator as well as those without.
5. Development and evaluation of specialized aids, including overlays or shields for learning the keyboard and key operations, to facilitate beginning student use of the calculator.
6. Preparation of instructional materials using the above aids for teaching efficient key fingering.
7. Provision of guidelines and suggestions for application across curriculum areas (e.g., social studies) by regular and/or special teachers (e.g., resource, itinerant).
8. Inclusion of appropriate activities at each math level which are related to daily living skills, prevocational, and vocational skills of visually handicapped students.
9. Preparation and inclusion of professional guidelines and adequate math instructional and supportive materials for teachers who will teach use of the calculator to students.
10. Provision of all written materials in large print and braille.
11. Development of audio-tutorial materials for students who are able to use them.

Section 4: Discussion

Discussions other than those referred to in the previous sections emphasized the widespread use of the hand held calculator, its importance as an aid to facilitate computation and problem solving for blind students, its increasing use in the elementary grades, the calculator as a logical extension of pencil and paper, and its potential for making mathematics fun and more interesting for blind students.

Section 5: Additional Information

Learning basic concepts with limited-function ABLE™ calculators: K-1 (Texas Instruments, Inc., 1977)

The K-1 instruction program was developed as an adjunct to established arithmetic curricula in kindergarten and first grade. It utilizes the specially designed ABLE calculator, which is adaptable to students' growth in understanding of mathematical concepts. As children are ready for new activities, instructors may easily snap out an ABLE face and replace it with a more advanced face, to complement the child's development.

The eight activity units included in the K-1 package are designed to encourage a basic understanding of quantitative thinking as early as possible in a child's education. In actual classroom use, it has been demonstrated that ABLE calculators can play an important role in this process. Teachers have found, for instance, that children can "make" numbers on ABLE calculators before they have learned to write numerals with pencil and paper. Preschoolers often chant number names without understanding that each word represents a certain number of objects. With ABLE calculators, however, children rapidly learn to associate number names with cardinality. Used as one part of a comprehensive teaching strategy, the ABLE (ABstract Linking Electronically) calculator can act as a responsive, motivating, instant-feedback tool linking a child's manipulative, physical experiences with abstract numeral description or representation of those experiences.

Encourages student discovery

Discovery and exploration by the children themselves are basic to the program. Although the materials themselves have a defined structure, their format for use is flexible; students can interact with activities alone or in small peer groups. Typically, a child should be encouraged to work with activities a total of one hour per week, perhaps divided into four fifteen-minute sessions which would be added to regular classroom arithmetic lessons.

All materials in the K-1 program are designed to provide the young child with pleasurable experiences using, playing with and actually constructing numbers as part of developing basic math skills. The package's challenging exercises and limited function ABLE calculators can play an important and enjoyable role in teaching and learning elementary mathematics concepts--linking the concrete, visual, oral and abstract experience of numerals, while constantly adapting to a child's developing skills.

Basic sequence of K-1 activities

K-1 materials are arranged according to a basic learning sequence, beginning with number recognition and ending with addition and subtraction. However, the package has been designed to allow the instructor maximum flexibility in classroom use, because no one is better able to judge students' needs and abilities than the teacher. While respecting the basic sequence of activities,

teachers may choose alternate learning paths to reflect individual teaching styles and varying levels of student comprehension.

Group 1: Recognition.

Children learn to recognize, sort and sequence numerals, as well as recognize and handle the calculator. Numerals are distinguished by shape and sorted according to sameness. Sequencing is introduced by ordering of objects or symbols.

Group 2: Counting.

Children begin to acquire basic concepts for addition, and later multiplication, through association with object groups and number names. ABLE displays link three forms of learning: seeing the numeral, hearing the number name and feeling the number of corresponding objects.

Group 3: More than-Less than.

Children develop concepts of estimation and number conservation. They discover ways to quantify the "more than" or "less than" of a situation. Through activities with coins, they are introduced to differences between quantity and value.

Group 4: Plus-Minus.

Students recognize and develop the correspondence between Arabic numeral symbols and appropriate cardinal numbers, including zero, and are introduced to more complex concepts such as computation of number sentences, inverse operations and subtraction.

4-6: Introductory enrichment.

A student-motivating learning activity package can be easily incorporated into existing upper elementary curricula.

These introductory materials for grades four through six were specially developed to help upper elementary teachers explore the unique educational potential of the calculator by supplementing their scheduled curricula with enrichment activities. Over 50 introductory activities reflecting student and teacher feedback have been developed for classroom use. These activities, designed to encourage student participation and involvement, range in difficulty and concept sophistication. They follow an open-ended format for individual and small group interacting, but may be expanded in scope to include an entire class. Thus, the package is flexible enough to accommodate differing instructional styles and encourage individual goal-oriented teaching.

The calculator is carefully integrated into each activity, not as a replacement for basic concept instruction, but rather as a fundamental learning tool--providing students with immediate feedback and the ability to make rapid retrials and repetitive calculations.

Topics explored

These activities utilize the calculator to allow students to explore areas such as:

- Basic arithmetic operations
- Basic problem solving
- Successive approximations and estimation
- Graphing and averaging
- Decimal arithmetic
- Mathematics of very large and very small numbers
- Simple statistics
- Logic and deduction

Also included are general exploration activities to familiarize students with the calculator and its use in analysis involving repetitive calculations.

Materials included

This learning program comes complete with materials needed to easily incorporate and manage calculator activities into existing mathematics programs:

- Teacher's guide
- More than 50 activity cards providing student direction
- Student worksheets in duplicator master format
- Color-coded folders for activity cards, game boards and worksheets
- Sufficient plastic counting squares and cubes (2 cm. per side) for an average-sized class of students
- Stick-on labels for cubes and squares
- Two rechargeable TI-1205 calculators

WORKSHOPS

Calculators in Kindergarten: Lawrence Hall of Science

The National Science Foundation is supporting Lawrence Hall of Science, University of California, Berkeley, in holding workshops with parents and teachers. Each two-day workshop focuses on:

K-6 calculator activities for the classroom. These range from counting and place value activities for the lower grades to decimal activities for upper elementary grades.

Teaching strategies that emphasize problem solving and new approaches to difficult concepts.

Unconventional uses of the calculator. This will include several activities for a special calculator developed by EMC^2 staff.

CALCULATOR PROJECTS IN THE SCHOOLS

Hawthorne, Frank: Hand Calculator Project. Bureau of Mathematics Education, State Education Department, New York. 1973-1974

This study involved sixth grade children over a period of one year. Teachers had the students use the calculator for checking work, solving word problems, finding averages and working with probability, functions and sequences.

Montana Council of Teachers of Mathematics: The Elementary Hand Calculator Project. Columbus High School, Columbus, Montana. 1975-

In the fall of 1975, ten teachers of grades 3-6 gathered together to discuss possible uses of the calculator in their classrooms. After the meeting, teachers went back to their schools and began implementing some of the ideas that were generated. Some teachers integrated the machines into the regular curriculum, while others used them only for enrichment. At the end of the year, the general consensus was that students' attitudes had improved, their problem solving skills were better, their understanding of decimals had increased, and their computational skills had not declined.

Elementary Mathematics Concepts with Calculators. Lawrence Hall of Science, University of California, Berkeley, California. 1974-

EMC^2 is a calculator-based curriculum development project for primary and upper elementary grades. The calculator is used to teach a variety of concepts. Most of the activities in the program are written as games.

REFERENCES

Caravella, Joseph R.: Minicalculators in the Classroom. National Education Association of the United States, 1977.

The author explores the positive contributions of the minicalculator for basic education.

Immerzeel, George; Electronic Hand Calculators: The Implications for Pre-College Education. Final Report, National Science Foundation, February 1976.

In this position paper, Immerzeel provides examples of topics and activities which might be introduced in grades K-3, 4-6, 7-8 and 9-12.

NCTM: The Arithmetic Teacher, Volume 23, Number 7, November 1976.

This entire issue is devoted to the hand calculator. Included are ideas for classroom use of the calculator, as well as articles on the pros and cons of calculator use and results of recent research.

Moursund, David: Readings on Calculators and Computers in the Elementary School, Department of Computer Science, University of Oregon, October 1976.

The calculator section of this book discusses the capabilities of calculators and differences between calculators and computers. The book also contains sample activities and a report on how these activities worked in a particular classroom in Oregon.

NIE Report of the Conference on Needed Research and Development on Hand-Held Calculators in School Mathematics, June 1976.

This report summarizes the state of calculator technology. Included is a discussion of mathematics education and curriculum development in relation to the calculator. In addition, members of the conference drew up guidelines and recommendations for future research and development in these areas.

Suydam, Marilyn: Electronic Hand Calculators: The Implications for Pre-College Education. Final Report, National Science Foundation, February 1976.

This report provides a comprehensive examination of the arguments for and against the use of calculators in the classroom. Included is a list of studies and projects on hand calculators and desk calculators. Much of the statistical information on calculator use and sales is now obsolete.

Usiskin, Zalmud, and Bell, Max (in Suydam)

The authors discuss their analysis of the textbooks currently available for elementary grades and make suggestions for curriculum changes. They also suggest ways in which calculators can be incorporated into the current curriculum.

APPENDIX 2

COMPUTATION AND PROBLEM SOLVING FOR YOUNG ADULTS

A self-instructional program

using the APH Student Speech Plus Calculator

by

William Emile Lamon, Anthony Evancic,

and Tuck Tinsley III

American Printing House for the Blind, Inc.

Louisville, Kentucky

1978

TABLE OF CONTENTS

SECTION E: THE CALCULATOR IN DAILY LIVING

ELEMENTARY COMPUTATION

A self-instructional program

using the APH Student Speech Plus Calculator

by

Tuck Tinsley III, Anthony Evancic,

and Bob Glass

American Printing House for the Blind, Inc.

Louisville, Kentucky

1979

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

*optional

ELEMENTARY PROBLEM SOLVING

A self-instructional program

using the APH Student Speech Plus Calculator

by

Anthony Evancic, Tuck Tinsley III,

and Bob Glass

American Printing House for the Blind, Inc.

Louisville, Kentucky

1979

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

APPENDIX 3

Manual I Contents

Part V Multiplying

A. Basic multiplying
B. Advanced multiplying
C. Multiplying for experts

Part VI Dividing

A. Basic dividing
B. Advanced dividing
C. Dividing for experts

Part VII Multiplying and dividing in the same problem

Part VIII Working with decimals

A. Keying in decimals
B. Money
C. Adding and subtracting decimals
D. Multiplying and dividing decimals

Part IX Fractions and the calculator

A. Changing fractions to decimals
B. Changing mixed numbers to decimals

* Part X Properties of numbers and operations

A. Commutative property of addition
B. Commutative property of multiplication
C. Additive property of zero
D. Multiplicative property of one
E. Multiplicative property of zero

* Optional

Manual II Contents

A. Reviewing fractions
B. Applications

* Part IX Properties of operations

A. Associative property of addition
B. Associative property of subtraction
C. Distributive properties

Part X Percent

A. Using the percent key
B. Percent key in problem solving - Part I
C. Percent key in problem solving - Part II

Part XI The square root key

* Optional

APPENDIX 4

APH Speech Plus Project: Consultants and Field Evaluators

Anthony H. Evancic
Mathematics Teacher
Philadelphia Public Schools
Philadelphia, Pa.

Stephanie Richards
Mathematics Teacher
Indiana School for the Blind
Indianapolis, Ind.

Margaret Ritchie
Vision Specialist
Pasadena Unified School District
Pasadena, Ca.

Tuck Tinsley III
Mathematics Teacher
Florida School for the Deaf and Blind
St. Augustine, Fla.

Sue Young
Mathematics Teacher
Tennessee School for the Blind
Nashville, Tenn.

Dr. Jack Price
Superintendent
Vista Unified School District
Vista, Ca.